MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LV. DECEMBER 14, 1894. No. 2

Captain W. DE W. ABNEY, C.B., R.E., D.C.L., F.R.S., President, in the Chair.

George Cox Bompas, F.G.S., F.R.G.S., 121 Westbourne Terrace, Hyde Park, W.;
Bryan Cookson, Oakwood, Wylam, R.S.O., Northumberland; and
Lieut. Basil Taylor, R.N., H.M.S. *Blake*, North American Station,

were balloted for and duly elected Fellows of the Society.

The following candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended:—

Edwin Bare, Ruthven Villa, Hainault Road, Leytonstone (proposed by James Glaisher);
Vincent Joseph Bouton, B.Sc., 9 Lansdowne Terrace, Hampton Wick (proposed by Arthur Cottam);
Henri Deslandres, D.-ès-Sc., Astronome-adjoint à l'Observatoire de Paris (proposed by Captain W. de W. Abney);
Comte A. de la Baume Pluvinel, 7 rue de la Baume, Paris (proposed by Captain W. de W. Abney);
George Darley Lardner, Commissary-General, 6 Princes Road, Wimbledon (proposed by R. A. Gregory);
C. W. D. Perrins, Davenham Bank, Malvern (proposed by the Rev. F. J. Eld);
Charles A. Post, 21 Washington Square, New York, U.S.A. (proposed by Harold Jacoby); and

Charles Roberts, 6 Bramerton Street, King's Road, Chelsea, S.W. (proposed by Adam Hilger).

Mr. J. E. Drower, Mr. W. B. Gibbs, and Mr. H. P. Hollis were appointed Auditors of the Treasurer's accounts for the year 1894.

One hundred and five presents were announced as having been received since the last meeting, including, amongst others—

A series of sixteen memoirs from the *Comptes Rendus*, &c., by M. Deslandres, presented by the Author, and copies on glass of nine spectrum photographs of the solar prominences, &c.; Détermination des constantes pour la réduction des clichés pris à Helsingfors, pour la construction du carte du Ciel, par A. Donner, presented by the Author; Radiant Suns, by Agnes Giberne, presented by the Author; Three volumes, containing a series of drawings of Sun-spots, presented by the Rev. F. Howlett; Publications of von Kuffner's Observatory, Vienna, vol. iv., presented by the Observatory; Lund Observatory Zone Observations $+35°$ to $+40°$, presented by the Observatory; Scheiner's Treatise on Astronomical Spectroscopy, translated, revised, and enlarged by E. B. Frost, presented by Professor Frost; Scheiner, Untersuchungen über den Lichtwechsel Algols, presented by Dr. L. Becker.

A Re-determination of the Epoch Correction and Mean Motion for Hansen's Lunar Tables from Meridian Observations of the Moon, 1750–1892. E. J. Stone, M.A., F.R.S., Radcliffe Observer.

In the present paper it is proposed to apply the views which I hold of the physical bases of the measures of time adopted in practical astronomical work to a re-determination of the epoch constant and mean motion in Hansen's Lunar Tables.

The results of all the meridian observations of the Moon made at Greenwich between 1750 and 1882, and those made at the Radcliffe Observatory, Oxford, from 1880 to 1892, will be included in the discussion.

The residuals give in column (3) of the following table have been taken from Airy's determinations of the mean errors in longitude of Damoiseau's Tables, *Memoirs*, vol. xxix., but they have been corrected for those parts of the differences of the Greenwich sidereal times which correspond to the beginning of the "unit day," which have usually been acknowledged and allowed for, in passing from the data adopted in Carlini's Tables to the data adopted in Le Verrier's Tables; and these corrections have been carried into all the residuals given in column (3).

The residuals, 1847–1892, have been obtained from direct

comparisons between Hansen's Lunar Tables and observations made in the usual manner.

My views on time-measurement are the direct mathematical consequences of the necessary continuity of our measures of time and of length, and the assumed truth of the three following working hypotheses :—

1. The law of universal gravitation.
2. The constancy of the Sun's mass.
3. The uniformity of the rotation of the Earth around its axis.

Sensible constancy during the whole period over which our investigations extend may be understood instead of absolute constancy.

These working hypotheses would have to be abandoned if it could be shown that, subject to the necessary continuity of our measures of time and of length, they led to results inconsistent with the facts of observation.

But, subject to the truth of these working hypotheses, the symbol, f, which expresses the accelerating effects of the Sun's mass, adopted as the unit of mass, at the unit of length, in the unit of time, cannot be changed in evaluating the gravitational effects of the different masses so long as the same units of length and of time are adopted.

To assume otherwise, and that different numerical values, f_1, f_2, f_3, &c., might be assigned to f in the investigation of the disturbing effects of the planetary masses on the motions of *Mercury*, *Venus*, the Earth, and the Moon, would be to assume, in practice, that the law of universal gravitation was not true. And the more accurately the differential equations of motion were formed and integrated with the use of different values f_1, f_2, &c., for f and the more exact the observations, the more evident would become the divergency between the mathematical results thus erroneously obtained and the facts of observation. Different numerical values can be assigned to f in our mathematical work by the adoption of different units of length and of time, but not otherwise. The numerical values which can be assigned to f are necessarily connected with the different units which we can adopt in such a way that $f \propto$ directly as the square of the interval of time which is adopted as the unit, and inversely as the cube of the length which is adopted as the unit.

But if ω denotes the constant angular velocity of the Earth about its axis, the numerical values which can be assigned to ω in our mathematical work are subject to the condition that they vary directly as the interval of time which is adopted as the unit. It follows, therefore, that, whatever unit of time we may adopt, the numerical values which are assignable to the $\sqrt{f}$ and ω in our mathematical work must be such that the ratio $\sqrt{f} : \omega$ is an absolute constant so long as the same unit of length is adopted. If, therefore, in the investigations of the heliocentric motion of the centre of gravity about the Sun we eliminate the

quantity f from our equations by the condition that $f = a^3n^2$, where a is a linear quantity which may, by a proper selection of the unit of length, be made $= 1$, and n is the coefficient of t in the expression of the heliocentric longitude of the Earth, it follows that the ratio $\omega : n$ is an absolute constant for any possible units of length and of time that we can adopt; and that the angles n and ω can only be found from observation subject to the condition $\frac{\omega}{n}$ is an absolute constant, and we can no more change n in our equations without an alteration of the unit of time than we can change ω or f.

The necessary conditions to preserve the same value of f in the lunar and solar theories when subsidiary conditions such as $f = a^3\mu^2$ are introduced, and μ is taken as the coefficient of t in the expression of the geocentric longitude of the Moon, are usually satisfied by the introduction of the condition that the ratio $\mu : n :: 1 : m$, where m is an absolute constant; and the results thus obtained should be exact, provided the numerical value ultimately assigned to μ is found on the scale of time-measurement fixed by the numerical value ultimately assigned to n; and the value of m is thus deduced from the ratio of two angular velocities referred to the same unit.

And what is true of ω and n will be equally true of Ω and N, if Ω denotes the mean motion of the meridian in right ascension measured from the true equinox, and N the coefficient of t in the expression for the geocentric longitude of the Sun, also measured from the true equinox. We shall have, therefore, in order to find accurate values of Ω and N from observation to introduce the condition that the ratio $\Omega : N$ is an absolute constant, whatever unit of length and of time we may adopt.

The differences between my results and those which have hitherto met with acceptance entirely turn upon the point whether the condition $\frac{\omega}{n}$, an absolute constant, is a fundamental condition which must be satisfied in order that our gravitational investigations can be exact after we have introduced into them the condition $f = a^3n^2$ or $f = n^2$, and $\mu : n :: 1 : m$, m being a constant.

The condition $\frac{\Omega}{N}$, an absolute constant, leads to the condition that Ω may be expressed under the form

$$(2\pi \frac{N}{N_0} + N) = 2\pi + N + 2\pi \frac{N - N_0}{N_0},$$

which cannot, therefore, $= 2\pi + N$ unless N happens to be identically equal to N_0, a definite angle for a definite epoch. For any other adopted angle N, we have, therefore,

$$\Omega_1 = 2\pi \frac{N_1}{N_0} + N_1 = 2\pi + N_1 + 2\pi \frac{N_1 - N_0}{N_0},$$

and therefore

$$\Omega_1 - \Omega = N_1 - N + 2\pi \frac{N_1 - N}{N_0}.$$

Astronomers have hitherto duly allowed for the effects of the term $N_1 - N$, but have overlooked the term

$$2\pi \frac{N_1 - N}{N_0}$$

in the difference $\Omega_1 - \Omega$; and *it was in this way that Hansen determined, from a discussion of observations*, the epoch correction and mean motion adopted in his tables which, if my views are correct, are necessarily defective, because results obtained in terms of one scale of time-measurement fixed by an adopted angle, N, were compared with observational results to obtain which another scale of time-measurement fixed by an adopted angle, N_1, had been employed.

The corrections, δS, given in column (7) of the following table are the effects on the tabular mean longitudes due to the neglect of the terms

$$2\pi \frac{N_1 - N}{N_0},$$

computed from the values N_1 and N used by astronomers before and after 1864. The effects of these terms are certainly important ; the only question at issue is whether they are, or are not, necessary if the continuity of our measure of time is to be preserved. I maintain, of course, that they are necessary, and I have simply traced the consequences of their application.

The difference between Hansen's and Le Verrier's values of N is but slight, and can easily and directly be allowed for by the transformation of Hansen's expressions, so far as they depend on the Sun's position, before proceeding to the determination of the constants involved in the periodical terms with the corrected values of the epoch constant ϵ and the mean motion μ.

Reference No.	(1) Years grouped.	(2) Mean Year.	(3) Tabular *minus* Observed D to 1851 H 1848–1892.	(4) Correction to reduce D to H in Mean Longitude.	(5) Correction to D for Hansen's Long Inequalities.	(6) Sum of the three preceding Columns and Hansen – Observed when the Corrections δS are neglected.	(7) Correction for δS usually neglected.	(8) Sum of the two preceding Columns, and Hansen – Observed afforded by Errors in Epoch and Mean Motion.	(9) Hansen *minus* Observed with New Epoch and Mean Motion.
			″	″	″	″	″	″	″
1	1750–1759	1754·5	+ 3·13	−27·83	+26·62	+ 1·92	−87·90	−85·98	−0·93
2	1755–1764	1759·5	+ 1·31	−25·03	+25·87	+ 2·15	−83·89	−81·74	−0 54
3	1760–1768	1764·0	+ 0·23	−22·51	+24·84	+ 2·56	−80·28	−77·72	+0 01
4	1765–1773	1769·0	− 1·52	−19·69	+23·29	+ 2·08	−76·27	−74·19	−0·31
5	1769–1778	1773 5	− 3·14	−17·14	+21·56	+ 1·28	−72 65	−71·37	−0 96
6	1774–1782	1778·0	− 3·51	−14·57	+19·52	+ 1·44	− 9·04	−67·60	−0·65
7	1779–1787	1783 0	− 3·16	−11·72	+16·94	+ 2·06	−65·03	−62·97	+0·12
8	1783–1791	1787·0	− 3·89	− 9·44	+14·65	+ 1·32	−61·81	−60·49	−0·48
9	1788–1796	1792·0	− 4·62	− 6·56	+11·55	+ 0·37	−57 80	−57·43	−1·27
10	1792–1801	1796·5	− 2·91	− 3·96	+ 8·57	+ 1·70	−54·19	−52·49	+0·20
11	1797–1805	1801·0	− 1·03	− 1·36	+ 5·45	+ 3·06	−50·58	−47·52	+1·70
12	1802–1810	1806·0	− 1·30	+ 1·55	+ 1·85	+ 2·10	−46·56	−44·46	+0·91
13	1806–1815	1810·5	− 1·11	+ 4·18	− 1·46	+ 1·61	−42·95	−41·34	+0·56
14	1811–1819	1815·0	+ 0·42	+ 6·81	− 4·77	+ 2·46	−39·34	−36·88	+1·56
15	1816–1824	1820·0	+ 1·19	+ 9·76	− 8·43	+ 2·52	−35·32	−32·80	+1·78

Reference No.	(1) Years grouped.	(2) Mean Year.	(3) Tabular *minus* Observed D to 1851 H 1848–1892.	(4) Correction to reduce D to H in Mean Longitude.	(5) Correction to D for Hansen's Long Inequalities.	(6) Sum of the three preceding Columns and Hansen—Observed when the Corrections δS are neglected.	(7) Correction for δS usually neglected.	(8) Sum of the two preceding Columns, and Hansen—Observed affected by Errors in Epoch and Mean Motion.	(9) Hansen *minus* Observed with New Epoch and Mean Motion.
16	1820–1829	1824·5	+ 0″·90	+ 12″·41	− 11″·64	+ 1″·67	− 31″·71	− 30″·04	+ 1″·08
17	1825–1833	1829·0	+ 0·93	+ 15·08	− 14·74	+ 1·27	− 28·10	− 26·83	+ 0·82
18	1830–1838	1834·0	+ 1·35	+ 18·06	− 17·99	+ 1·42	− 24·08	− 22·66	+ 1·14
19	1834–1842	1838·0	+ 0·77	+ 20·45	− 20·41	+ 0·81	− 20·87	− 20 06	+ 0·65
20	1839–1847	1843·0	− 0·40	+ 23·44	− 23·17	− 0·13	− 16·86	− 16·99	− 0·13
21	1843–1851	1847·0	− 2·13	+ 25·85	− 25·14	− 1·42	− 13·65	− 15·07	− 1·29
22	1848–1856	1852·0	− 1·50	...	...	− 1·50	− 9·63	− 11·13	− 1·20
23	1852–1860	1856·0	− 2·24	...	...	− 2·24	− 6·42	− 8·66	− 1·82
24	1857–1865	1861·0	− 1·89	...	...	− 1·89	− 2·50	− 4·39	− 1·40
25	1861–1869	1865·0	+ 0·85	...	...	+ 0·85	− 0·54	+ 0·31	+ 0·22
26	1866–1874	1870·0	+ 5·43	...	...	+ 5·43	0·00	+ 5·43	+ 1·49
27	1870–1878	1874·0	+ 7·90	...	...	+ 7·90	0·00	+ 7·90	+ 0·88
28	1875–1883	1879·0	+ 10·37	...	...	+ 10·37	0·00	+ 10·37	− 0·51
29	1879–1887	1883·0	+ 13·16	...	...	+ 13·16	0·00	+ 13·16	− 0·80
30	1884–1892	1888·0	+ 16·99	...	...	+ 16·99	0 00	+ 16·99	− 0·82

A discussion of the residual errors in column (8), with an allowance for the fact that the mean annual residuals refer to the middle and not the commencement of the year, gives for the necessary corrections to epoch, ϵ, and mean motion, μ, the following values :—

$$\delta\epsilon = +49''\cdot994 + 0''\cdot385 = 50''\cdot379$$

$$\delta\mu = -0''\cdot7705$$

the epoch being 1800 Jan 0·0. G.M.T.

The residual errors, for the thirty equations from which the corrections to the epoch and mean motion have been deduced, are given in column (9).

But on account of the use of residuals indirectly deduced from comparisons made through Damoiseau's Tables, I have given as a check the mean annual residuals for all the years 1847–1892 for which I have results available from direct comparisons between Hansen's Tables and observations. It will be seen that, although the observations of the last forty years cannot have been used by Hansen in the deduction of data for the formation of his tables, the agreement between his results and those of observation are remarkably close. The mean of the residual errors in longitude for the years 1847–1892 is only $-0''\cdot32$, and the mean error only $1''\cdot17$.

Mean Excess over Observation of the Moon's Tabular Place in Longitude for the years 1847 *to* 1892, *as computed from Hansen's Tables uncorrected and with the corrected Epoch and Mean Motion determined from the Meridian Observations of the Moon*, 1750 *to* 1892.

Hansen *minus* Observed
(for all the Annual Results available from direct comparison with Hansen's Tables).

Year.	Uncorrected.	Corrected.	Year.	Uncorrected.	Corrected.
	″	″		″	″
1847	+0·51	+1·04	1870	+ 4·65	+0·70
1848	−0·53	+0·04	1871	+ 6·71	+1·99
1849	−1·08	−0·48	1872	+ 7·05	+1·56
1850	−0·97	−0·34	1873	+ 7·95	+1·69
1851	−1·93	−1·27	1874	+ 8·96	+1·93
1852	−1·57	−0·87	1875	+ 9·51	+1·71
1853	−2·18	−1·46	1876	+ 9·45	+0·88
1854	−2·34	−1·59	1877	+ 8·91	−0·43
1855	−1·40	−0·62	1878	+ 7·93	−2·18
1856	−1·51	−0·69	1879	+ 9·29	−1·59
1857	−2·41	−1·56	1880	+10·71	−0·94
1858	−2·61	−1·73	1881	+10·32	−2·10
1859	−2·49	−1·57	1882	+12·45	−0·74
1860	−3·62	−2·67	1883	+14·71	+0·75
1861	−2·95	−1·97	1884	+14·65	−0·08
1862	−2·72	−1·71	1885	+15·20	−0·30
1863	−1·54	−0·49	1886	+15·34	−0·93
1864	+0·12	+0·80	1887	+15·70	−1·34
1865	+1·22	+1·13	1888	+17·68	−0·13
1866	+2·07	+1·21	1889	+17·37	−1·21
1867	+3·35	+1·72	1890	+18·02	−1·33
1868	+3·97	+1·57	1891	+19·30	−0·83
1869	+4·12	+0·95	1892	+19·69	−1·20

The results here obtained are the converse of those which I have annually brought before the Society for some years. In those comparisons between Hansen's Tables and the observations of the Moon I have accepted Hansen's Tables with the epoch and mean motion which he found for observations made during a period when the data of Carlini's Solar Tables were employed; and I corrected the times, t, found as at present to reduce them to the scale for which the values t and μ had been found. In the present investigation I have conversely corrected the times determined, 1750-1864, and reduced them to the present scale of time-measurement, and then re-determined the epoch and mean motion on the scale at present adopted. But as this gives a period of at least forty additional years for the determination of the mean motion, the result may be expected to be more accurately found on its scale than that found by Hansen.

I have not, at present, attempted to correct the determination of the constants involved in the periodic terms. Such a step appears useless until the great fundamental principles at issue in these questions have been definitely settled. But if anyone will assume that the time as now found is absolutely correct, or that the tabular places are correctly referred to the meridian with Le Verrier's value of N, or, in other words, if

$$2\pi \cdot \frac{N - N_0}{N_0} \cdot t$$

is a negligible angle, and the corrections

$$\delta\epsilon = +50''\cdot379$$
$$\delta\mu = -0''\cdot7705$$

are carried into the mean longitude of Hansen's Tables, the tabular results thus obtained will agree very closely indeed with the results of observation.

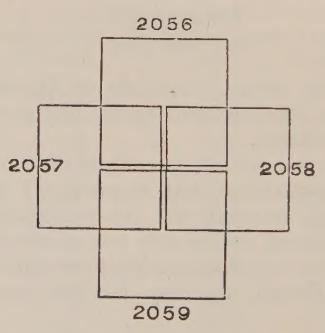
I am engaged in examining the effects of the rejection of one of Hansen's long inequalities, but at present I can only say that if this were done the necessity for the corrections δS is equally apparent. The residual errors are not so small as before, but they are, perhaps, not much larger than are admissible if the old observations are affected, as may be the case, with sensible systematic errors.

Account of the Measurement and Comparison of a Set of Four Astrographic Plates, made at the Royal Observatory, Greenwich. By W. H. M. Christie and F. W. Dyson.

Before commencing the systematic measurement of the astrographic plates it seemed desirable to make a tolerably complete discussion of the measures in one particular case. For this purpose four catalogue plates were taken by Miss Everett on 1894 May 21. Each plate had three exposures of 6^m, 3^m, and 20^s respectively, the guiding star being placed successively at three of the angles of a square formed by spider lines 20″ apart in N.P.D. and R.A. respectively. The 3^m image is thus 20″ south of the 6^m, and the 20^s image (for stars of ninth magnitude and upwards) 20″ due west of the 6^m image. The right ascension, declination, and mean distance of the plate during exposure from the meridian are :—

No. of Plate.	R.A. h m	Declination. °	E. of Meridian. m
2056	16 50	67	70
2057	16 40	68	40
2058	17 0	68	40
2059	16 50	69	20

Thus the plates are arranged as in the accompanying diagram, a quarter of each plate overlapping one quarter of each of the two adjacent plates.



At Professor Turner's suggestion, a glass scale in connection with a viewing microscope was used for the measurement of the photographs, and it was found, as will be seen from the results here given, that this simple and rapid method gave the position of the star's image relatively to the *réseau* lines with sufficient accuracy. It was arranged to use a glass diaphragm with two scales at right angles, divided to $\frac{1}{20}$th of a millimetre (representing 3″ in the sky), which was made by Mr. Simms, the diaphragm being placed in the focal plane of the microscope of the astrographic micrometer. By means of the perpendicular slides

of the micrometer, the star's image is placed accurately at the intersection of the two scales, and the position of the *réseau* lines relatively to it is read off on the two cross-scales by estimation to $\frac{1}{200}$th of a millimetre (0·001 of a *réseau* interval), representing $0''\cdot3$ in the heavens. The coordinates of the 6^m and 3^m images of each star were measured both by Miss Everett (A. E.) and Miss Russell (A. R.). The measured places of the stars on two overlapping plates were compared by the method given by Professor Turner in the *Monthly Notices* for 1893 November (vol. liv. pp. 11–25). This method consists in deducing from the measured coordinates of a star on one plate what would be its coordinates on the second had the plates no errors arising from error of setting, of orientation, and differential refraction which were not equally shared by the two plates, the deduced places being then compared with the actual measured places on the second plate, and corrected by means of linear formulæ. If we call x_1 and x_2 the measured coordinate of the same star on the two plates, then from x_1 a quantity x_{12} has been derived from the assumed settings of the plates : this does not differ far from x_2.

The quantities $x_2 - x_{12}$ have been formed for all the separate stars, and it is assumed that these can be represented by the formula

$$ax_2 + by_2 + c.$$

The quantities a, b, c, d, e, f are determined, and the quantities

$$x_{12} + ax_2 + by_2 + c, \qquad y_{12} + dx_2 + cy_2 + f,$$

are the coordinates which the star would have had on the second plate, as given by the measures on the first plate, allowing for the errors of setting, &c., of the two plates.

The constants a, b, c, &c., were determined in several different ways. The results showed :—

1. That it was desirable to use a fairly large number of stars, say forty or fifty.

2. That the stars used for this comparison need not be confined to those which were within a limited distance of the centres of the overlapping plates.

3. That by dividing the stars into four groups—those on the top half, those on the bottom half, those on the left half, those on the right half of the quarter plate—and by taking the means for these four groups, the determination of a, b, c, &c., was practically as accurate as that obtained by employing the method of least squares.

When the plates were compared two and two in this manner, it was anticipated that a and e would vanish, and that b would $= -d$. This amounts to assuming that the only errors not common to the two plates were errors of centring and orientation. When a slight error in the theoretical formulæ of transformation had been corrected (*Monthly Notices*, 1894 June, Supplementary Number, p. 573), the values found for the constants were as follows :—

TABLE I.

Different determinations of the constants connecting two plates.

Plate 2059 to 2057.

Measurer	Exposure m	No. of stars used	*a*	*b*	*c*	*d*	*e*	*f*
A.R.	6	59	+·00017	+·00131	+·0244	−·00102	+·00017	−·1004
A.E.	6	32	+·00014	+·00114	+·0264	−·00095	+·00002	−·1010
A.R.	3	46	+·00031	+·00116	+·0159	−·00102	+·00022	−·1037
A.E.	3	34	+·00032	+·00103	+·0171	−·00106	−·00017	−·1011
	Mean	... ...	+·00025	+·00116		−·00101	+·00006	

Plate 2056 to 2057.

Measurer	Exposure m	No. of stars used	*a*	*b*	*c*	*d*	*e*	*f*
A.R.	6	48	+·00020	+·00172	+·0271	−·00174	+·00003	−·1248
A.E.	6	42	+·00015	+·00158	+·0268	−·00195	+·00017	−·1220
A.R.	3	40	+·00031	+·00166	+·0208	−·00170	−·00005	−·1260
A.E.	3	40	+·00052	+·00162	+·0197	−·00156	−·00016	−·1258
	Mean	... ...	+·00030	+·00165		−·00174	00000	

Plate 2056 to 2058.

Measurer	Exposure m	No. of stars used	*a*	*b*	*c*	*d*	*e*	*f*
A.R.	6	58	−·00035	+·00022	−·0303	−·00041	−·00006	−·0126
A.E.	6	54	−·00015	+·00020	−·0298	−·00021	+·00003	−·0105
A.R.	3	46	−·00029	+·00029	−·0231	−·00050	−·00012	−·0129
A.E.	3	50	−·00029	+·00025	−·0231	−·00035	−·00009	−·0117
	Mean	... ...	−·00027	+·00024		−·00037	−·00006	

Plate 2059 to 2058.

Measurer	Exposure m	No. of stars used	*a*	*b*	*c*	*d*	*e*	*f*
A.R.	6	68	−·00006	−·00040	−·0271	+·00042	+·00002	+·0289
A.E.	6	60	−·00010	−·00035	−·0279	+·00041	−·00003	+·0291
A.R.	3	60	−·00007	−·00042	−·0240	+·00033	+·00010	+·0266
A.E.	3	56	−·00010	−·00029	−·0255	+·00044	−·00020	+·0289
	Mean	... ...	−·00008	−·00036		+·00040	−·00003	

An examination of this table shows—

1. A difference between the values of c as determined from the measures of the 6^m and 3^m images. This arises from different errors in the bisection of the guiding star at the two exposures. There seems also to be a very small difference in the value of f.

The quantities c and f are expressed in decimals of a *réseau* interval (5′), so that 0·001 denotes 0″·3. The quantities a, b, d, e are coefficients of the coordinates of a star, which in the extreme case may multiply quantities as large as 12 *réseau* intervals. Thus an error of 0·0001 in a, b, d, or e may give rise to an error of 0·0012 of *réseau* intervals, or 0″·36.

2. The quantities a and e cannot be taken = 0. The above table shows that a is not zero for 2059−2057, 2056−2057, 2056−2058: this may possibly arise from tilt in the plates. But the main part of b and d, as they are nearly equal and of opposite sign, seems to arise from difference of orientation error. The value of this difference in angular measure is (irrespective of sign) 4′ 43″, 1′ 18″, 5′ 50″, 1′ 3″ for the four comparisons.

3. The discordances between the values of the constants as given by the different measurers seem to be rather large in some cases, but it should be noticed that the discordances near the mean of the stars compared are much smaller. Thus, in 2059–2057, $c+7a+7b$, as determined by A.R. and A.E., only differ by ·0006 for the 6^m exposure, and by ·0004 for the 3^m exposure, although c as determined by the two differs by ·0020 and ·0012.

The sum of the constants a, b, d and e for a closed ring of plates ought to be zero. Changing the sign in the second and fourth case, so as to give constants for reducing plate 2059 to 2057, 2057 to 2056, 2056 to 2058, and 2058 to 2059, we obtain −·00024, +·00011, −·00004, +·00003 for the sum of the constants a, b, d and e respectively.

The discordances seem to arise from accidental errors in the measurement, and irregularities in the photographic image. The effect of these will be diminished if the means of the measures of the 6^m and 3^m images are considered as the coordinates of the star. In this way both images are used, and hardly any additional work is given to the computer beyond taking the means. A direct comparison has also been made—

1. Between the measures of the same image by the two measurers.

It was found that the personality of the measurers was very small, if at all appreciable. As a mean of 850 measures,

$$\text{AE}-\text{AR} = -0''\cdot1 \text{ in the horizontal coordinate}$$
$$= -0\cdot2 \text{ in the vertical coordinate.}$$

The mean discordance between the measures of the same image by the two observers was found to be $\pm 0''\cdot36$.

2. Between the measures of the 6^m and 3^m images by the same observer : the mean discordance was in this case $\pm''\cdot36$. There was just the same range as in the measures of the same star by the two measurers.

3. The mean discordance between a measured coordinate of a star on one plate and its coordinate computed from the corresponding measure on an overlapping plate was found to be $\pm''\cdot45$. The fact that this is so slightly in excess of $\pm''\cdot36$, the mean discordance between the measures of the same image by the two measurers, shows the validity and accuracy of the method adopted for the comparison of overlapping plates.

The following table is given to exhibit the accordance between the measures of different mesaurers of images of different exposures and of images on different plates :—

There are eight different measures to be compared. Miss Everett and Miss Russell's measures on plate 2057 of the 6^m images are given directly. From their measures of the 6^m images on plate 2059, the coordinates on plate 2057 were deduced by application of the constants given in Table I. Similarly from their measures of the 3^m images on plate 2059 coordinates on plate 2057 were deduced. Finally, the mean difference between the coordinates of the 6^m and 3^m images was applied to the latter. The mean of the eight different values was taken, and the discordances formed.

Columns 1 and 2 are the approximate coordinates of a star on plate 2057, given in *réseau* intervals, and measured from the centre of the plate.

Columns 3, 4, 5, 6 are the discordances from the mean of Miss Russell's and Miss Everett's measures of the R.A. coordinate of the 6^m and 3^m images on plate 2057. Columns 7, 8, 9, 10 refer to corresponding measures on plate 2059. The remaining eight columns give similar discordances for the other coordinate.

TABLE II.

Comparison of Different Measures on Two Plates.

A Coord. on 2057.	B Coord. on 2057.	*Discordance of A Coordinate from Mean of 8.* 2057 A.R. 6m.	2057 A.E. 6m.	2057 A.R. 3m.	2057 A.E. 3m.	2059 A.R. 6m.	2059 A.E. 6m.	2059 A.R. 3m.	2059 A.E. 3m.	*Discordance of B Coordinate from Mean of 8.* 2057 A.R. 6m.	2057 A.E. 6m.	2057 A.R. 3m.	2057 A.E. 3m.	2059 A.R. 6m.	2059 A.E. 6m.	2059 A.R. 3m.	2059 A.E. 3m.
+ 2·8	− 0·6	−″·21	+″·09	−″·01	−″·61	+″·39	+″·39	−″·01	−″·01	+″·01	+″·31	+″·21	+″·21	+″·01	+″·01	−″·39	−″·39
3·3	0·2	+·83	+·23	+·43	−·77	+·23	...	+·13	−1·07	−·15	−·45	−·85	−·55	+1·35	...	+·65	...
5·1	0·2	+·10	−·50	...	...	+·40	...	...	...	+·10	−·20	...	...	+·10	...	...	...
5·7	1·1	−·07	−·07	−·17	−·17	−·07	...	+·43	+·13	−·37	−·07	−·47	−·17	−·07	...	+·43	+·73
12·4	0·6	−·59	−·29	−·09	+·51	−·29	+·31	−·09	+·51	−·36	−·06	+·14	−·46	+·24	−·36	+·14	+·74
12·5	− 0·6	−·34	−·34	+1·06	−·14	−·04	−·34	+·16	...	−·04	−·34	+·16	−·14	+·26	−·04	+·16	...
0·4	+ 0·4	−·50	−·20	·00	+·60	+·10	...	·00	...	−·60	·00	+·50	−·40	+·60	...	−·10	...
8·9	0·2	−·18	−·48	+·02	+·62	−·18	−·48	−·28	+·92	−·64	−·34	−·44	−·14	−·04	+·26	+·76	+·76
10·1	0·6	−·18	−·48	−·58	+·62	−·18	−·18	+·32	+·62	+·05	−·55	−·05	+·25	+·05	−·25	−·05	+·55
10·6	0·3	+·15	−·45	...	...	−·15	+·45	...	...	+·37	−·83	...	...	+·07	+·37	...	...
0·7	1·9	−·30	+·00	−·40	−·40	+·60	...	+·50	...	·00	+·30	+·20	+·50	−·30	...	−·70	...
3·2	1·9	+·14	+·14	+·34	+·34	−·46	...	+·04	−·56	+·61	+·61	+·81	+·51	−·59	...	−·99	−·99
4·6	1·3	+·12	−·18	+·02	+·02	−·48	...	+·52	...	+·30	−·30	−·10	−·70	·00	...	+·80	...
6·0	1·4	+·09	+·09	−·61	−·31	+·09	+·09	+·29	+·29	+·31	−·29	−·09	+·21	+·01	−·29	−·09	+·21
8·6	1·7	−·30	...	...	...	+·30	...	...	...	−·15	...	...	...	+·15	...	...	...
1·2	2·7	−·05	−·05	−·45	−·45	+·55	...	+·45	...	−·25	+·05	−·35	−1·25	+1·25	...	+·55	...
1·5	2·6	+·16	−·44	−·24	+·36	−·14	−·14	+·36	+·06	+·01	−·89	+·21	−·39	+·91	−·29	+·51	−·09
5·5	2·8	+·24	+·24	−·16	+·14	+·24	−·36	−·16	−·16	−·29	−·59	−·39	−·39	+·31	+·31	+·51	+·51
5·8	2·7	+·48	+·48	+·38	−·52	+·18	−·12	+·38	+·08	−·21	+·39	+·29	+·29	+·09	+·09	−·01	−·91

A Coord. on 2057.	B Coord. on 2057.	*Discordance of* A *Coordinate from Mean of* 8. 2057 A.R. 6^m.	A.E. 6^m.	A.R. 3^m.	A.E. 3^m.	2059 A.R. 6^m.	A.E. 6^m.	A.R. 3^m.	A.E. 3^m.	*Discordance of* B *Coordinate from Mean of* 8. 2057 A.R. 6^m.	A.E. 6^m.	A.R. 3^m.	A.E. 3^m.	2059 A.R. 6^m.	A.E. 6^m.	A.R. 3^m.	A.E. 3^m.
7·6	2·6	−″·33	+″·87	+″·17	+″·17	−″·33	−″·33	+″·17	−″·43	+″·01	+″·01	+″·21	+″·21	+″·31	−″·29	−″·39	−″·09
8·2	2·8	−·56	+·04	+·24	+·24	−·56	+·04	−·36	−·06	+·24	+·24	+·14	+·14	+·24	−·36	−·16	−·46
+ 8·3	2·3	−·59	+·01	+·21	+·21	−·89	+·31	−·09	+·81	−·33	+·27	+·17	+1·07	−·03	−·33	−·43	−·43
− 1·7	3·6	−·29	−·59	−·39	−·39	+·61	+·31	−·09	+·81	+·42	+·12	−·28	−·58	+·42	−·18	+·02	+·02
− 1·4	3·5	+·20	+·20	...	...	−·40	...	...	...	·00	·00	...	...	·00	...	...	...
+ 3·2	3·2	+·61	+·91	+·21	−·09	−·59	−·29	−·39	−·39	+·31	+·31	−·09	−·09	+·01	−·29	−·09	−·09
5·4	4·0	+·12	...	+·28	...	+·12	...	+·02	...	+·65	...	−·35	...	−·55	...	+·25	...
11·4	3·2	−·50	−·20	·00	+·30	−·20	...	+·60	...	+·15	+·45	−·25	−·25	+·15	...	−·25	...
+ 10·7	3·8	−·30	...	...	...	+·30	...	...	...	+·15	...	...	...	−·15	...	...	...
− 1·7	4·7	+·23	+·23	−·77	−·47	−·37	...	+1·03	+·13	−·16	−·16	−·26	+·04	−·76	...	+·94	+·34
+ 4·9	4·9	+·19	+·19	−·21	+·09	+·19	...	−·21	−·21	+·23	+·23	+·13	−·17	−·67	...	+·13	+·13
6·6	4·7	+·50	+·50	−·50	−1·10	+·20	+·20	+·10	+·10	+·16	−1·04	+·06	−·54	+·46	+·46	+·36	+·06
8·7	4·3	−·14	+·46	−·24	−·24	−·14	−·14	+·06	+·36	−·03	+·27	+·17	+·47	−·03	−·33	−·43	−·13
8·8	4·5	+·39	−·51	−·01	+·59	−·21	+·09	−·31	−·01	−·03	−·03	+·17	+·17	+·27	−·33	+·47	−·73
12·8	4·7	+·30	...	...	...	−·30	...	...	...	+·60	...	...	...	−·60	...	...	...
1·6	5·3	+·39	+·09	−·01	+·29	+·09	...	−·31	−·31	+·57	−·03	+·77	+·17	−·33	−·63	−·13	−·43
3·0	5·2	+·55	+·25	−·25	−·55	+·55	...	−·55	...	+·15	−·15	+·05	+·05	+·15	...	−·25	...
6·5	5·2	+·19	+·49	+·09	+·39	−·11	−·11	−·51	+·09	+·46	+·46	−·24	+·36	−·44	−·14	+·06	−·54
7·1	5·1	+·15	+·15	−·55	+·35	+·15	...	−·25	...	+·20	−·10	−·20	+·10	−·40	...	+·40	...
+ 10·7	5·5	+·31	+·31	−·69	−·09	−·29	−·29	+·51	+·21	+·31	−·29	−·09	−·69	+·31	+·01	+·51	−·09
− 0·6	6·1	−·14	+·16	−·24	+·06	−·14	+·16	+·06	+·06	+1·14	−·36	−·16	−·16	−·06	−·36	−·46	+·44

G

A Coord. on 2057.	B Coord. on 2057.	*Discordance of* A *Coordinate from Mean of* 8. 2057 A.R. 6^m.	2057 A.E. 6^m.	2057 A.R. 3^m.	2057 A.E. 3^m.	2059 A.R. 6^m.	2059 A.E. 6^m.	2059 A.R. 3^m.	2059 A.E. 3^m.	*Discordance of* B *Coordinate from Mean of* 8. 2057 A.R. 6^m.	2057 A.E. 6^m.	2057 A.R. 3^m.	2057 A.E. 3^m.	2059 A.R. 6^m.	2059 A.E. 6^m.	2059 A.R. 3^m.	2059 A.E. 3^m.
+ 0·7	6·7	+ ″·06	+ ″·36	− ″·64	− ″·64	+ ″·66	...	+ ″·26	− ″·04	− ″·11	− ″·41	− ″·21	− ″·21	+ ″·49	...	+ ″·69	− ″·21
1·4	6·2	+ ·00	...	...	...	·00	...	...	...	+ ·30	...	...	...	− ·30	...	...	...
5·3	6·9	− ·25	− ·25	− ·15	+ 1·05	− ·25	+ ·05	− ·85	+ ·65	+ ·61	− ·29	+ ·21	− ·09	− ·29	− ·59	+ ·21	+ ·21
8·6	6·6	− ·36	− ·06	− ·16	+ ·74	− ·06	− ·05	− ·16	+ ·14	+ ·27	+ ·57	+ ·17	− ·43	− ·03	+ ·27	− ·43	− ·43
0·3	7·2	− ·30	...	...	...	+ ·30	...	...	...	− ·15	...	...	...	+ ·15	...	...	...
1·0	7·8	+ ·30	− ·30	+ ·20	− ·10	+ ·60	...	− ·70	...	+ ·70	+ ·10	− ·30	− ·30	+ ·10	...	− ·30	...
4·5	8·2	+ ·15	...	...	...	− ·15	...	...	...	+ ·30	...	...	...	− ·30	...	...	...
5·8	8·7	+ ·37	− ·53	...	...	+ ·67	− ·53	...	...	− ·08	− ·38	...	...	+ ·52	− ·08	...	...
5·9	8·8	+ ·10	+ ·10	...	...	− ·20	...	...	...	·00	− ·60	...	...	+ ·60	...	...	...
9·2	8·3	− ·15	...	...	...	+ ·15	...	...	...	− ·45	...	...	...	+ ·45	...	...	...
+ 3·0	9·9	+ ·15	− ·15	...	...	+ ·15	− ·15	...	...	·00	− ·60	...	...	·60	·00	...	...
− 0·8	10·2	+ ·35	− ·25	+ ·25	− ·35	+ ·05	+ ·35	− ·35	− ·05	+ ·35	− ·25	− ·65	− ·35	+ ·35	+ ·05	+ ·85	− ·35
+ 4·6	10·4	− ·21	− ·21	− ·31	...	+ ·09	+ ·69	+ ·59	...	− ·67	− ·07	+ ·43	...	+ ·23	− ·07	+ ·13	...
− 1·6	12·9	+ ·54	+ ·54	− ·46	+ ·14	− ·06	− ·06	− ·46	− ·16	− ·31	− ·61	+ ·79	− ·41	+ ·29	− **·31**	+ ·49	− ·11
+ 7·7	12·6	− ·24	+ ·36	− ·14	− 1·04	+ ·96	+ ·36	− ·14	− ·14	+ ·35	− ·85	+ ·85	− ·65	+ ·65	+ ·05	+ ·25	− ·65
8·6	12·3	+ ·44	+ ·44	− ·36	− ·66	+ ·44	+ ·44	− ·36	− ·36	+ ·41	− ·49	− ·29	− ·59	+ ·41	+ ·41	+ ·31	− ·29
1·8	13·4	+ ·46	− ·14	+ ·66	+ ·66	− ·14	− ·74	− ·24	− ·54	− ·55	+ ·05	+ ·55	+ ·25	+ ·05	− ·25	+ ·55	− ·65
+ 10·5	+ 13·2	− ·14	+ ·46	− ·54	− ·24	+ ·46	− ·14	+ ·36	− ·24	+ ·76	+ ·16	+ ·36	+ ·36	+ ·16	− ·14	− ·24	− 1·44
...	...	...	...	...	...	...	...	...	...	− ·15	...	...	...	+ ·15	...	...	...
Mean discordance		± ·29	± ·30	± ·31	± ·38	± ·30	± ·27	± ·30	± ·32	± ·30	± ·33	± ·31	± ·36	± ·31	± ·25	± ·38	± ·43

These discordances seem somewhat large in some cases, but it is to be remarked that they were obtained from the first measures made with the glass scale, and that none have been rejected, though later examination showed that they were sometimes rather rough in consequence of the want of familiarity of the measurers with their instruments. Nor has any correction been applied for the errors of *réseau*, or for distortion. Considering that these discordances are derived from the comparison of measures on two plates, they seem to show that a satisfactory degree of accuracy can be obtained by the simple method of measurement used.

On the Proper Motions of Three Stars in the Constellation Ophiuchus. By W. T. Lynn, B.A.

In the *Monthly Notices* for 1870 November I gave the proper motions, deduced from Airy's Greenwich Catalogues, of the double star 36 (A) *Ophiuchi* and of a star which in *Flamsteed* is the 30th catalogued in the constellation *Scorpio*, and is therefore called 30 *Scorpii* in Baily's *Flamsteed*, though Baily notes that it should have been included by *Flamsteed* in the constellation *Ophiuchus*, and it is therefore so arranged in the B.A.C., where it is given (without a constellation number) as No. 5813. In the Twelve-year Catalogue and in the two Seven-year Catalogues (it does not appear in the Six-year or in the Nine-year) Flamsteed's number, 30 *Scorpii*, is retained ; but in the Ten-year Catalogue (in which it is No. 2696) it is called in the text *Bradley* 2179.

I have thought it would be worth while to supplement my former paper by computing the proper motions of these stars from the later Greenwich Catalogues, and here set down all the places of the three which are given in them, from the first Seven-year to the Ten-year.

Authority.	Epoch.	A^1 Ophiuchi. R.A.	No. of Obs.	A^2 Ophiuchi. R.A.	No. of Obs.	Bradley 2179. R.A.	No. of Obs.
		h m s		h m s		h m s	
7-year for	1860	17 6 44·47	12	17 6 44·67	9	17 7 37·18	8
7-year „	1864	17 6 59·27	3	17 6 59·33	1	17 7 51·80	2
9-year „	1872	17 7 28·583	5	17 7 28·816	3	...	...
10-year „	1880	17 7 58·105	10	17 7 58·314	8	17 8 50·846	4
		N.P.D.		N.P.D.		N.P.D.	
		° ′ ″		° ′ ″		° ′ ″	
7-year for	1860	116 23 35·06	12	116 23 31·26	9	116 20 25·21	8
7-year „	1864	116 23 59·08	3	116 23 55·01	1	116 20 47·77	2
9 year „	1872	116 24 42·45	5	116 24 38·08	2	...	...
10-year „	1880	116 25 31·03	11	116 25 25·93	9	116 22 17·17	4

From these places we obtain the following annual variations :—

		A^1 Ophiuchi. R.A.	N.P.D.	A^2 Ophiuchi. R.A.	N.P.D.	Bradley 2179 R.A.	N.P.D.
		s	″	s	″	s	″
From the years	1860–64	+3·700	+6·00	+3·665	+5·94	+3·655	+5·64
,,	1864–72	+3·664	+5·42	+3·686	+5·38	[1864–1880]	
,,	1872–80	+3·690	+6·07	+3·687	+5·98	+3·690	+5·59
From whole period	1860–80	+3·682	+5·80	+3·682	+5·73	+3·683	+5·60

Now the geometrical precessions for the three stars are, for 1860, in RA. + $3^s{\cdot}718$, + $3^s{\cdot}718$, and + $3^s{\cdot}717$ respectively, in N.P.D. + $4''{\cdot}62$, + $4''{\cdot}62$, and $4''{\cdot}54$; and for 1880, in RA. + $3^s{\cdot}720$, + $3^s{\cdot}720$, and + $3^s{\cdot}719$, in N.P.D. + $4''{\cdot}514$, + $4''{\cdot}514$, and + $4''{\cdot}439$, the means of which may safely be used in obtaining the proper motions.

	In R.A. Annual Variation.	Annual Precession.	Resulting Annual Proper Motion.
	s	s	s
A^1 Ophiuchi	+3·682	+3·719	−0·037
A^2 Ophiuchi	+3·682	+3·719	−0·037
Bradley 2179	+3·683	+3·718	−0·035

	In N.P.D. Annual Variation.	Annual Precession.	Resulting Annual Proper Motion.
	″	″	″
A^1 Ophiuchi	+5·80	+4·57	+1·23
A^2 Ophiuchi	+5·73	+4·57	+1·16
Bradley 2179	+5·60	+4·49	+1·11

These values of the proper motions would seem to be entitled to considerable confidence. Those which I obtained in 1871 by comparing the places in the Greenwich Twelve-year Catalogue with the New Seven-year for 1864 were, in RA. − $0^s{\cdot}029$, − $0^s{\cdot}043$, and − $0^s{\cdot}042$ respectively, and in N.P.D. + $1''{\cdot}20$, + $1''{\cdot}05$, and + $1''{\cdot}17$; those adopted from Auwers in the Greenwich Ten-year Catalogue are, in R.A. − $0^s{\cdot}039$, − $0^s{\cdot}039$, and − $0^s{\cdot}039$, and in N.P.D. + $1''{\cdot}138$, + $1''{\cdot}138$, and + $1''{\cdot}134$. What makes these stars so especially interesting is the circumstance that the third, distant from the first two, which form a pair, by about $12'\ 21''$ in a great circle, partakes with them in the same large proper motion, amounting to about $1''{\cdot}27$ in a great circle.

Perhaps I may be allowed to add that I have compared the places of a considerable number of stars for which no proper motions are given in the Ten-year Catalogue with the corresponding places in the Twelve-year, and all that I have examined are small, with the exception of *Piazzi* III 170, for which I find the annual proper motion in RA. + $0^s{\cdot}005$ and in N.P.D. + $0''{\cdot}145$,

both smaller than those assigned in the B.A.C., the latter considerably so, the proper motion in N.P.D. there given amounting to + 0″·25.

Blackheath:
1894 *December* 7.

A Comparison of some Places of Stars observed at the Sydney Observatory with the Places of the same Stars as given in the Cape Catalogue, 1880. By H. P. Hollis.

The stars used in this comparison are contained in the latest publication from the Sydney Observatory, which was published in 1893, and gives the results of meridian observations made in the years 1879, 1880, 1881, in the form of annual catalogues for these years.

From these annual catalogues a catalogue has been formed for epoch 1880 of about 300 stars, all of which have been observed at least three times in either element, and only places which depend on at least three observations have been used in this comparison.

The places thus found have been compared with the places given in Mr. Stone's Cape Catalogue for epoch 1880, and Table I. gives the result of this comparison, the stars being arranged in order of R.A. and divided into hourly groups. The figures in columns 3 and 5 give the simple means of such groups.

TABLE I.

	R.A.		N.P.D.			R.A.		N.P.D.	
Limits of R.A.	No. of Stars.	Difference Sydney—Cape ×sin N.P.D.	No. of Stars.	Difference Sydney—Cape.	Limits of R.A.	No. of Stars.	Difference Sydney—Cape ×sin N.P.D.	No. of Stars.	Difference Sydney—Cape.
h h		s		″	h h		s		″
0–1	7	+0·080	5	+0·33	12–13	14	+0·026	11	−0·13
1–2	7	+0·058	8	+0·33	13–14	23	+0·055	22	−0·76
2–3	10	+0·140	9	+0·38	14–15	21	+0·116	20	−0·36
3–4	20	+0·224	20	−0·04	15–16	11	−0·054	10	−0·04
4–5	13	+0·202	13	+0·37	16–17	18	+0·055	18	−0·65
5–6	16	+0·098	16	+0·89	17–18	8	−0·011	8	+0·05
6–7	11	+0·082	10	+0·85	18–19	3	−0·050	3	+1·26
7–8	15	+0·093	14	−0·11	19–20	1	−0·030	1	+2·68
8–9	15	+0·041	15	+0·73	20–21	10	+0·006	10	−0·44
9–10	17	+0·015	16	+0·47	21–22	9	−0·001		0·36
10–11	20	+0·013	20	+0·52	22–23	9	+0·044	9	+0·03
11–12	18	−0·015	16	−0·17	23–0	5	+0·053	5	+0·42

This table calls for little comment. In many cases the number of stars in a group is too few to eliminate accidental errors. To form the next table the stars were arranged in order of N.P.D., divided into groups of about ten, and the weighted means of these groups taken, each difference being weighted according to the usual formula :

$$\frac{4mn}{m+n+\frac{1}{5}mn}.$$

TABLE II.

Differences arranged in order of N.P.D. and divided into groups of approximately ten stars. The weighted means of such groups are given.

R.A.				N.P.D.			
Approx. N.P.D. of group.	No. of Stars.	Wt.	Diff. of R.A. (S.−C.) ×sin N.P.D.	Aprox. N.P.D. of group.	No. of Stars.	Wt.	Diff. of N.P.D Sydney−Cape.
° ′			s	° ′			″
63 37	11	103	+0·049	63 42	9	41	+0·35
69 36	10	98	+0·025	69 36	10	43	+0·70
76 8	10	92	−0·004	76 32	9	42	+1·00
80 15	10	93	−0·003	80 15	10	51	+0·48
82 37	11	104	−0·019	82 44	10	60	+1·47
87 21	10	85	+0·008	87 21	10	49	+0·77
91 30	11	102	+0·013	91 34	10	58	+0·61
97 42	10	94	+0·018	97 42	10	65	+0·81
102 28	10	97	+0·038	102 28	10	58	+0·73
107 47	10	76	+0·042	107 44	9	43	+0·44
113 56	10	80	+0·053	114 1	9	55	+0·04
118 32	10	56	−0·008	118 32	10	52	+0·63
119 50	10	51	+0·056	119 50	10	51	+0·13
120 14	9	49	+0·070	120 14	9	45	−0·31
120 52	10	52	+0·142	120 52	10	51	−0·07
121 49	10	50	+0·070	121 49	10	51	+0·03
123 4	10	55	+0·110	123 4	10	50	−0·38
124 12	10	53	+0·049	124 12	10	54	−0·24
124 50	10	58	+0·143	124 50	10	50	+0·45
125 47	10	51	+0·225	125 47	10	53	+0·20
126 28	10	44	+0·187	126 28	10	48	+0·67
131 21	10	46	+0·126	131 21	10	48	−0·00
135 13	8	40	+0·085	135 3	10	55	−0·51
137 28	10	51	+0·038	137 23	9	42	−0·41
141 29	10	49	+0·124	141 29	10	51	−1·18
146 7	10	49	+0·086	146 7	10	53	−1·38
150 25	10	49	+0·036	150 25	10	56	−1·09
153 19	10	47	+0·296	153 16	9	45	−0·34
159 20	11	81	+0·054	159 49	10	73	−0·71

It will be seen that the differences of N.P.D. are comparatively large, but that there is a decided sequence, which is more obvious from Table III., where the means of the preceding results are taken in groups of five.

Table III.

Means of Differences arranged in order of N.P.D. and taken in groups of 50 Stars.

Approx. Mean N.P.D. of group.	Difference of R.A. Sydney − Cape ×sin N.P.D.	Difference of N.P.D. Sydney − Cape.	Correction of the form $+1''\cdot576\times\sin zd$ Sydney.
° ′	s	″	″
74 27	+0·010	+0·83	+1·20
97 22	+0·024	+0·69	+0·73
118 41	+0·061	+0·09	+0·14
123 56	+0·121	+0·01	−0·00
134 24	+0·109	−0·30	−0·29
152 24	+0·074	−0·89	−0·74
General Mean	+0·055	+0·09	

The latitudes of Sydney and of the Cape happen to be nearly identical, each being approximately 33° 54′. The N.P.D. of the fourth group in Table III. is therefore nearly that of the zenith. From the mean of this group in N.P.D. it may be inferred that the difference of the adopted latitudes of Sydney and of the Cape is not far from the truth. The means of the other groups seem to point to the want of an instrumental correction, depending on the zenith distance, to the observations of one or the other catalogues. No correction of this kind was applied to the Sydney observations, but determinations of horizontal flexure by the collimators gave a mean value for the flexure constant of $1''\cdot576$. The values of a correction of the form $+k \sin z.d$ with the above value of k, applicable to the Sydney observations of zenith distance, and therefore applicable with changed sign to these differences, are given in the last column of Table III.

Remarks on Three Volumes of Sun-spot drawings presented to the Society. By Rev. F. Howlett, M.A.

I have the honour of requesting the Society to accept what will, probably, be the *final instalment* of my solar drawings. Many thousands of spots great and small are therein depicted with the greatest care and, let me say, conscientiousness, of which I was capable.

The series, more or less continuous, extends over a period of about five-and-thirty years, and I may truly say the work has been a labour of love and of the deepest interest. I imagine (if I may say so without arrogance) that no such series of hand-

drawings, showing the minute details of the configurations and changes of the solar spots, exists.

If in this respect I am in error, I shall loyally yield the palm of superiority to any other brother observer, whether in England or any other part of the world.

Since the application of the marvellous and invaluable art of *photography* to celestial phenomena of every description, I have sometimes wondered whether, with the view of advancing any real knowledge of the Sun, it was worth my while to continue such a series of drawings ; and this has, for one reason, been the cause of very considerable gaps in the record. But encouraged by the plea on behalf of hand drawings of solar phenomena, made in an address to the members of the Royal Institution, a few years ago, by the late admirable and lamented Father Perry, I persevered in the work. Moreover, whilst an almost unbroken daily record of the solar disc on a small scale is preserved at our great National Observatory at Greenwich, it is only, I believe, at rare intervals that astronomy is enriched and instructed by such splendid details of the photosphere, faculæ, and solar spots as are furnished by the photographs of Professor Janssen more especially ; though, even in them, the sharp distinction existing between the umbræ and penumbræ is by no means satisfactorily shown. There is sometimes, in fact, no difference manifested at all.

I would now take this opportunity of saying that the main object I have had in view in continuing this series of drawings for so many years—through four periods of maximum solar spot activity and three of minimum activity—has been to test the theory first put forth by Professor Wilson, of Glasgow, as recorded in the *Philosophical Transactions* for the years 1774 and 1783. You all know what that theory is, as maintained in the *Transactions* with what was intended to be the most scrupulous care and attention, though, I cannot but now feel certain, with very imperfect instrumental means and appliances.

What these were is fully described in the *Philosophical Transactions* to which I have just alluded. Wilson's theory is, that owing to the way in which (according to his ideas) the penumbra in a spot *shelves down* towards the umbra of the same, the portion of the penumbra nearest to the Sun's centre will grow perspectively narrower and narrower, causing the umbra, which might be really *central* in the spot, to appear no longer central, but to lie close to the inner edge of the spot.

Now this, of course, *would* be the case if the spots were of that deeply depressed *crateriform* nature which almost all writers on physical astronomy have described them as possessing, but which my observations, made under most charmingly perspicuous conditions, have in almost every instance refuted. Some few spots, indeed, when lying close to the Sun's limb have appeared to favour slightly the Wilsonian hypothesis ; but, as Mr. Turner (now Savilian Professor at Oxford) remarked to

me last year in a letter, "one ought to know the *history* of a spot," meaning, "had it been duly ascertained whether or not the umbra of a spot under discussion to test the theory was *really central* or otherwise suitable for such an investigation?" And oftentimes I have found that such a knowledge of their history refuted the testimony to the Wilson theory which an isolated observation seemed to afford. Several such instances will be found in the eight volumes of my drawings.

It is, I believe, generally known that my method of observing the Sun is by projecting the solar image on a screen, placing the latter at such a distance from the eye-piece of the small refractor of 3 inches aperture as shall, with a magnifying power of 80 linear, produce an image of 32 inches in diameter, or about one inch to one minute of celestial arc, though I frequently scrutinise the spots with higher powers producing an image of twice that diameter, as well also as by direct vision with the aid of a Dawes' solar eye-piece.

I cannot too strongly recommend this use of a screen and a small handy refractor, which, with a light shutter adapted to a chamber window, can in a moment be applied for an observation. I have here a photograph of such a shutter, with its appliance of vulcanised indiarubber for clasping the tube of the telescope and keeping out all extraneous light.

I will not on this occasion weary the Fellows with any general description of the contents of these volumes. Those who are interested in the subject of which they form illustrations can, at their leisure, honour them with their attention. There is an index of the spots at the commencement of each volume, wherein are specified those instances which distinctly militate against the Wilsonian theory, as well as those which seem to favour it. There are in the three volumes presented to-day no less than fifty of the former, and only nine of the latter, the majority, if not indeed all of them, being really of no real worth on the Wilsonian side, because, as I have said, the umbræ were shown not to have been *central*.

The theory, in fact, will simply stand or fall by careful and sufficiently prolonged observation, which few, unfortunately, have had the time or disposition to carry out. But, so far as they have been able to do so, both Professor Spörer, of Munich, the late lamented Father Perry, Mr. Cowper Ranyard, the late Mr. Whipple, of the Kew Observatory, and several of my own private friends who have witnessed the behaviour of spots near the limb of the Sun are satisfied that the Wilsonian theory that the spots are funnel-shaped depressions is entirely erroneous.

Moreover, as I stated in a paper which I read before the British Association last year at Nottingham, by the courtesy of the Astronomer Royal and the staff under his administration I was allowed to institute a comparison between the testimony afforded by my own drawings and that of the photographic pictures there accumulated; and I think I may say in

every case I was borne out in my contention that the spots can in no sense be called cavernous. Nay, I make bold to say, that instead of the penumbra of a spot possessing *shelving sides*, sloping down towards the umbra, it (the penumbra) presents a *convex* surface ; that is to say, a curve conformable to the general contour of the solar orb.

Observation leads me to the conviction that the photospheric stratum (save where faculæ occur) consists of merely one layer of the so-called "rice-grain" entities—say about 1000 miles at most in thickness—in close contiguity to the subjacent penumbra ; which, again, can possess no greater thickness than the photosphere, or the umbræ (whose depth I do not profess to estimate) could not be seen *central* in the penumbræ (as I assert they do) when very near the limb. By "very near" I mean not more than some 40 or even 30 seconds only of arc.

Lastly, in contravention of statements put forth on high authority, no spot, however large, or supposing it to have ever so shelving sides, could possibly present the appearance of a *notch* when passing round the limb, but only the slightest possible *flattening* of the sphere at that point, unless indeed the spot were accompanied by a most abnormal and extraordinary piling up of facular matter north and south (but not at the same time east or west) of the penumbra. But this I have never myself witnessed, save in one rather doubtful case on 1862 August 4, as shown in sheet No. 86 of vol. ii.

The appearance of a notch has occasionally been seen in a *photograph* ; but that was simply in consequence of the lack of sufficient power in the already degraded light near the limb to depict the yet more degraded dusky spot.

The Annular Eclipse of the Sun 1894 *April* 6.

By C. Michie Smith.

The first contact was lost through clouds, but the last contact was well observed, as follows :—

	M.M.T. h m s
Prof. R. Ll. Jones	21 17 43·8
C. Michie Smith	21 17 42·3
K. V. Sivaramiah	21 17 43·4

A number of photographs were taken during the eclipse with the hope of obtaining signs of the Moon against the corona, but without definite success. The eclipse was not annular at Madras ; but as the magnitude of the eclipse was 0·96, the reduction in light was very marked and the meteorological effects were considerable, as is shown by the following table :—

Meteorological Observations at the Madras Observatory 1894 *April* 6.

h	m	Reduced Barom.	Thermometer in Shade. Dry.	Thermometer in Shade. Wet.	Humidity.	Sun. Maximum Thermometer.	Remarks.
19	0	29·926	76·9	75·1	92	...	
19	15	...	78·1	75·8	90	...	
19	30	...	79·1	76·2	87	...	Dew began to be deposited about 19h 30m and continued for nearly an hour.
19	45	29·947	79·8	76·8	87	82·1*	* In the shed.
20	0	·957	79·0	76·6	89	86·5	
20	15	·960	79·0	76·8	90	86·8	
20	30	·961	80·4	77·4	87	96·5	
20	45	·962	81·9	77·8	83	109·8	
21	0	·969	81·8	77·5	82	115·3	
21	15	·973	83·5	78·8	80	120·5	
21	30	·971	84·4	78·8	77	128·3	

The normal rise of the barometer between 7 A.M. and 9 A.M. at this season is 0·028 in. Many of the observers who have to telegraph to Simla the weather observations at 8 A.M. used the code word for "dark gloomy weather"!

A number of photographs taken by amateurs throughout the presidency, including one of the annular phase taken at Cuddapah, were forwarded to the Observatory, but none of them contained any features of special interest.

The Solar Eclipse of 1894 *September* 29.

The following observations were obtained :—

Observer	First contact. M.M.T. h	m	s	Last contact. M.M.T. h	m	s
C. Michie Smith	21	3	27·6	22	29	2·9
K. V. Sivaramiah	...			22	29	2·3

Madras Observatory:
1894 *October* 25.

Total Eclipse of the Sun, 1894 September 29.

Extract from the Meteorological Log (9,399) kept on board the SS. "Yarrawonga." By Captain H. G. Thomas.

(Communicated by the Secretaries.)

This eclipse was looked for on the morning of the 29th, but we were unable for clouds to note the time of first contact. As we were to the northward of the line of central shadow, it was observed by us as a partial eclipse. The central phase took place at 9.20 A.M., corresponding to G.M.T. $28^d\ 16^h\ 31^m\ 42^s$, the Sun's diameter being about $\frac{3}{4}$ hidden, disclosing a crescent at the underneath part. The sky keeping clear, the eclipse was observed to finish at 10.57 A.M., corresponding to G.M.T. $28^d\ 18^h\ 8^m\ 42^s$. Position of ship at central phase—Lat. 7° 17′ S., Long. 70° 12′ E. Position of ship at finish—Lat. 7° 6′ S., Long. 69° 58′ E.

Meteorological Office:
1894 *November* 8.

Observations of the Transit of Mercury on 1894 November 10 at Sidmouth, Devon. By A. F. Lindemann.

1. The observations were made on Muttersmoor, about 630 feet above sea, near Sidmouth, in N.L. 50° 41′ 28″ and W.L. 3° 16′ 2″, by Professor H. H. Turner, of Oxford, and A. F. Lindemann, of Sidmouth.

2. *Instruments.*—Professor Turner : Refractor by W. Wray, aperture 3·04 inches, focal length 40 inches, magnifying power 155, measured by observations on a graduated staff at noon, November 11. Eye-piece pulled out and image thrown on card screen firmly attached to telescope by wooden bars, so as to give an image of the Sun 3 inches in diameter. (It was intended to have this image 6 inches in diameter, but in the hurry of putting up the instrument after the shower mentioned below the wooden bars were attached too far up the telescope tube, and could not be altered in time. A black cloth was used to shut out stray light, and the observations were found very easy.)

A. F. Lindemann : Refractor by T. Cooke & Sons, 2·44 inches free aperture, 37 inches focal length. Eye-piece magnifying power 55, similarly determined on November 11.

3. *Watches.*—The pocket watches of the party were used and were compared as follows, being denoted by the following initials :—

(1) Miss Dora Davidson's watch, D.D.
(2) Professor Turner's watch, H.T.
(3) A. F. Lindemann's watch, L.

D.D. h m s	H.T. h m s	D.D.—H.T. s	Date.
3 21 0	3 20 53·8	+ 6·2	Nov. 10
5 11 20	5 11 15	+ 5·0	10
10 56 30	10 56 28	+ 2·0	10
4 52 30	4 53 1·5	−31·5	11

L. h m s	H.T. h m s	L.—H.T. m s	Date.
3 22 0 p.m.	3 20 10	+1 50	Nov. 10
4 32 30	4 30 38	+1 52	10
5 43 0	5 41 6·7	+1 53·3	10
10 40 0	10 37 51·7	+2 8·3	10
4 36 30	4 34 16·8	+2 13·2	11

4. Comparison with Sidereal Clock (T. Cooke & Sons) at Sidholme Observatory :—

	h m s	h m s	
H.T. =	5 38 43·7	= 20 54 0·0	Cooke
L. =	5 42 37·0	= 20 56 0·0	„

5. *Error of Sidereal Clock.*—Three stars (*α Cephei*, *β Aquarii* and *ε Pegasi*, one N. and two S. of the zenith) were observed with the Sidholme transit, and gave a clock error of $7^m\ 23^s{\cdot}0$ (fast) at $21^h\ 30^m$ sidereal on November 10. From further observations on November $12^d\ 1^h$ (sid.) the clock was found to be $7^m\ 51^s{\cdot}2$ fast, giving a rate of $0^s{\cdot}57$ per hour gaining.

6. *Error of Watches on* G.M.T.—From the above comparisons and observations the errors and rates of the watches at the time of observation were found to be—

	m s	s
D.D.	1 18·2	slow, losing 0·21 per hour.
H.T.	1 23·7	„ „ 0·07 „
L.	0 28·6	fast, gaining 0·57 „

7. *Observations of Ingress.*—Arrived at observing-station at $2^h\ 42^m$ G.M.T., $2^h\ 52^m$ quite overcast, $3^h\ 8^m$ raining hard, but clearing in W. The party sheltered in the carriage and compared watches as in §3. About $3^h\ 30^m$ cleared up and instruments quickly erected ; all ready and quite clear at $3^h\ 49^m$.

Professor Turner's observation by watch D.D. (time taken by Miss Dora Davidson) :—

	h m s		h m s
D.D.	3 55 0	"slight cloud."	G.M.T. = 3 56 18·2
	3 55 30	"Mercury suspected."	3 56 48·2
	3 56 44·5	"first thread of light."	3 58 2·7

10 seconds later well separated.

A. F. Lindemann observed internal contact by

	h	m	s
L.'s watch at	3	58	15
Watch error			−28·6
G.M.T. =	3	57	46·4

15 seconds later separation quite distinct; $4^h\ 10^m$ G.M.T. quite cloudy.

The white spot was not seen, although looked for directly, without success, by both observers.

On the late Transit of Mercury. By the Rev. S. J. Johnson, M.A.

November 10 was mild here, with frequent showers, one of which ended too slowly at the time of ingress, when the Sun came out at $3^h\ 58^m\ 12^s$. The internal contact of *Mercury* with the Sun seemed to have taken place hardly more than 5 seconds. This would be later than the predicted time by about $\frac{3}{4}$ minute. The disc of the planet was jet black. It seemed to resemble a shot on a bright background. No halo was perceptible, though it was carefully looked for. By way of trial, I took some micrometer measurements of diameter, the mean of which came out $8''{\cdot}8$; quite as near as could be expected, considering the Sun's limb was boiling and the planet very tremulous. The transit was visible for exactly twenty minutes, when the Sun disappeared behind a small black cloud. No power higher than 50 on a $3\frac{1}{4}$-inch telescope could be employed.

Melplash Vicarage, Bridport:
December 8.

Observations of the Transit of Mercury, 1894 *November* 10, *made at Grahamstown, Cape of Good Hope.* By L. A. Eddie.

The sky was clear in the vicinity of the Sun as the moment approached for external contact at ingress, though there were many light clouds in the east, and lateral strata of fine cirri clouds lying on the western horizon and extending to a little below the position of the Sun. The air was warm and calm, but a low barometer bespoke that a change was at hand, which was already indicated by an unsteady condition of the atmosphere around the Sun's periphery, causing a constant succession of rapid undulations, which I feared would intercept the detection of external contact. There were seven conspicuous sun-spots on the solar disc, in three groups of two spots each and one single one just within the western border. The instrument used was a 3-inch refractor, powers 32 and 120.

Notwithstanding the scollops around the Sun's disc, I was fortunate enough to detect, as near as possible, the very earliest contact of *Mercury* with the Sun's limb at the exact point where I was expecting it, having selected this point as being about the required 98° from the north. I suddenly caught the faintest enlargement, as it were, of one of the undulations, and called to my assistant with the timepiece, who recorded $5^h\ 25^m\ 38^s$. It was impossible to bisect the planet with any degree of accuracy, owing to the atmospheric undulations encroaching upon this tiny disc and diminishing it. I was therefore a little late with this estimation, which was recorded at $5^h\ 26^m\ 58^s$. The estimated time of internal contact was also retarded, the planet seeming to adhere to the periphery of the Sun, though no black drop phenomenon was apparent, the unsteady atmosphere, resulting in the agitation of the Sun's limb, alone seeming to prevent the earlier detection of the completion of the planetary circle, and thus causing a lagging at internal contact. The time recorded for this event was $5^h\ 27^m\ 38^s$; but as soon as the planet had fully freed itself from contact, I could perceive that it should have been recorded some seconds earlier.

I could not trace the remainder of the planet's disc outside the Sun's limb after it had begun to enter upon his face, as I was able to do with *Venus* during transit in 1882; but this might have been owing to the smallness of *Mercury* and the unsteady definition. When fully on, the planet appeared to be surrounded by a dusky ring of grey light, in depth about one-third of the diameter of the planet itself, and somewhat less brilliant than the general solar surface.

No bright spots were detected within the planet's disc, but the latter appeared to me at times to be of a deep chocolate brown rather than black.

When the Sun had descended behind the bank of cirri clouds it closely resembled *Jupiter*, the transparent clouds forming the belts, and the planet *Mercury* a satellite in transit.

The Sun set at $6^h\ 8^m$, Cape uniform time, about 43 minutes after *Mercury* had entered his disc; the planet had then advanced about one-seventh of the chord to be travelled across the face of the Sun.

Grahamstown, longitude 26° 31′ 18″ E.; latitude 33° 19′ 7″ S.

	Cape uniform time. d h m s	Aperture. inches.	Power.
External contact	10 5 25 38	3	32
Planet bisected	10 5 26 58	3	32
Internal contact	10 5 27 38	3	32

Grahamstown:
1894 *November* 12.

Observations of the Transit of Mercury on 1894 *November* 10.

By Lieutenant Basil Taylor, R.N.

(*Communicated by the Secretaries.*)

The first external contact is very approximate, as I did not know exactly the point of the Sun's limb to watch.

The first internal contact is timed as accurately as possible, but may be slightly too early through my inexperience in observation.

I was unable to see the Sun at the time of egress, as it was obscured by heavy clouds.

The instrument employed was a 2·25-inch refractor with power of 80 ; the telescope mounted on a tripod. The times were taken with two watches, which were compared shortly before with three chronometers on board this ship : the comparisons are given below.

Comparisons were also taken of the same chronometers after the observations, which gave the same errors.

Place of observation : Lat. 32° 19′ 10″ N., Long. 64°49′15″ W.

	Times by (i) h m s	Times by (ii) h m s
External contact at Ingress	23 36 30	(?)
Internal contact at Ingress	23 37 35	23 38 7

	h m s	
Error of (i) on G.M.T.	4 19 34·5	slow.
Error of (ii) on G.M.T.	4 19 1·5	slow.

Comparisons of watches (i) *and* (ii) *with Chronometers* A, B, *and* D.

	h m s		h m s
A.	2 26 0	A.	2 26 30
(i).	9 36 26	(ii).	9 37 29·5
Error of A. on G.M.T.	$0^h\ 29^m\ 59^s$	fast.	
	h m s		h m s
B.	12 35 0	B.	12 35 30
(i).	9 37 41	(ii).	9 38 44
Error of B. on G.M.T.	$1^h\ 22^m\ 15^s$	slow.	
	h m s		h m s
D.	3 30 30	D.	3 31 0
(i).	9 40 13	(ii).	9 41 17
Error of D. on G.M.T.	$1^h\ 30^m\ 41^s$	fast.	

The errors of the chronometers were ascertained by observations of the Sun with sextant and artificial horizon on various dates during the month of October.

H.M.S. "Blake," North American Station :
1894 *November* 11.

Result of Micrometer-comparisons of Uranus and α Libræ, 1894 October 5. By John Tebbutt.

In consequence of cloudy weather, no other observations than those now sent could be secured near the conjunction of the planet and star. The 8-inch equatorial refractor with its excellent filar micrometer and lowest power, 74, was employed, one revolution of the adopted screw being 17″·869. Twenty comparisons were obtained in the evening twilight on the single transit thread of the micrometer, with the corresponding number of bisections of the star and planet for declination. As the limbs of the planet, though steady, were not well defined, the centre of the disc was observed for both right ascension and declination. The following are the results, the apparent place of the star being taken from page 353 of the *Nautical Almanac*, and that of the planet being interpolated with third differences from page 267 of the same work. The corrections for refraction are insensible.

	R.A. h m s	Declin. ° ′ ″
Apparent place of Star	14 45 1·97	−15 36 16·8
Observed difference of Planet and Star ...	+6·28	−13·4
Correction for Parallax	+0·02	− 0·2
Concluded Geoc. App. place of Planet's Centre	14 45 8·27	−15 36 30·4
Geoc. App. place from *Nautical Almanac* ...	14 45 8·59	−15 36 31·6
Correction for *Nautical Almanac*	−0·32	+1·2

The Windsor mean time corresponding to the concluded position is October $5^{d}\ 6^{h}\ 22^{m}\ 13^{s}$.

Windsor, N.S. Wales:
1894 October 13.

Observation of a Daylight Occultation of Antares, 1894 October 31. By John Tebbutt.

The circumstances of this rare phenomenon were kindly calculated for my observatory by Mr. R. T. A. Innes, of Sydney, and Mr. Joseph Brooks, the officer in charge of the trigonometrical survey of the colony. The evening turned out beautifully clear, and excellent observations were obtained of the phenomenon by means of the Cooke filar micrometer and a power of 138 on the Grubb 8-inch equatorial. The telescope was first turned on the star about an hour before the calculated time of disappearance at the Moon's dark limb, but the image was badly defined and flaring. The steadiness and definition, however, wonderfully improved as the afternoon advanced, and at the time of the first

phase were satisfactory. Shortly before the disappearance the star was brought midway between the position threads of the micrometer, which were, of course, set parallel to the equator. The star was observed to disappear instantaneously between the threads at $20^h\ 12^m\ 23^s{\cdot}0$ per sidereal chronometer corrected, the corresponding local mean time being $5^h\ 34^m\ 1^s{\cdot}4$. As the Sun's upper limb was observed to disappear on the visible horizon at $6^h\ 20^m\ 29^s$ it follows that the first phase was observed $46\frac{1}{2}$ minutes before direct sunlight ceased. The telescope was kept clamped in declination in order that the position threads of the micrometer might serve to point out approximately the place where the star would reappear on the bright limb. By allowing a little for the change of refraction in the interval, I fortunately had my eye directed to the exact place of reappearance. The irradiation of the crescent limb was much reduced by the strong twilight, and the star was caught at $21^h\ 21^m\ 13^s{\cdot}8$ (per sidereal chronometer corrected) as a small round white disc, which gradually became brighter as its distance from the limb increased, and in a minute or so shone out with its usual ruddy glare. Nothing was seen of the well-known companion. Considering the strong twilight and the high power employed, it was hardly possible to distinguish it. The deduced mean time of reappearance is $6^h\ 42^m\ 40^s{\cdot}9$. As both phases were well observed, and the occultation was nearly central, the observations will afford an accurate place of the Moon when the longitude of the observatory is definitively settled. On reviewing an experience of thirty years of occultation work, I find that I had previously observed four occultations of *Antares* and one of *Spica* on a dark sky, but that I had never before observed an occultation of a fixed star in full sunlight. I conclude, therefore, that the observation just recorded is a rare one. I may add that according to Mr. Brooks's calculation *Spica* will be occulted soon after noon on the 24th instant, and *Antares* will again be occulted shortly after sunrise on December 25, civil time. I may also add that I will do my best to observe these important phenomena.

Private Observatory, The Peninsula, Windsor, N.S. Wales :
1894 *November* 3.